Comparing Cosmological Constraints
form X-ray Galaxy Clusters
with PLANCK Results

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Overview

• Cosmological constraints from REFLEX

• Effect of massive neutrinos

• Evidence for a local underdensity
Predicted Cluster Luminosity Function with parameter dependence

Sensitive dependence on $\sigma_8$ and $\Omega_m$

background cosmology
structure formation $P(k)$
Mass function (Tinker)
$L_X$-mass scaling relation
X-ray luminosity function
The REFLEX Galaxy Cluster Survey

REFLEX II 911 clusters \[ F_X > 1.8 \times 10^{-12} \text{ erg s}^{-1} \text{ cm}^{-2} \]

REFLEX I: 18 runs La Silla  \hspace{1cm} \text{REFLEX II: 9 runs ESO 3.6m/NTT}

Sample descriptions:  \hspace{1cm} \text{Böhringer et al. 2001, 2004, 2013}
Observed and predicted X-ray luminosity function

Prediction from a flat $\Lambda$CMD model $\Omega_m = 0.27$, $\sigma_8 = 0.80$ and REFLEX II XLF

Böhringer et al. 2014
Influence of the scaling relation on the cosmological constraints

Böhringer et al. 2014

slope + 5%, normalization + 10%, scatter + 10%

Böhringer et al. 2014
REFLEX and PLANCK cluster
and PLANCK and WMAP CMB constraints

Planck Collaboration 2013
Hinshaw et al. 2013

Böhringer et al. 2014

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Prediction for PLANCK CMB cosmology

Böhringer et al. 2014
Results from REFLEX II, the SDSS MaxBCG sample and from the 400 deg$^2$ survey

Rozo et al. 2010

Vikhlinin et al. 2009
local sample: 49 clusters
at $\langle z \rangle = 0.05$
Effect of massive neutrinos
The effect of massive neutrinos

Neutrino mass $M_\nu = 0, 0.06, 0.17, 0.4, 0.6$ eV

Böhringer et al. 2014, to be submitted
Constraints on $A_s$ and $\Omega_m$ for $M_\nu = 0, 0.17, 0.4, 0.6$ eV

Formal consistency for $M_\nu = 0.45 \pm 0.2$ eV

Local Cosmography
REFLEX Cluster Density Distribution as Function of Redshift

Böhringer et al. 2014
REFLEX Cluster Density Distribution at $z < 0.06$

Böhringer et al 2014
Local Underdensity in the Galaxy Distribution in the South Galactic Cap

Whitbourn & Shanks 2014

(see also Keenan et al. 2012)
REFLEX Cluster Density Distribution in the North and South Galactic Cap (in the Southern Sky)

South galactic cap region

North galactic cap region in South

Böhringer et al. 2014
Conclusions

- Cosmological constraints on $\sigma_8$ and $\Omega_m$ from REFLEX, best local cluster sample, disagrees with PLANCK CMB within standard $\Lambda$CDM framework

Unlikely solutions:

- Clusters need to be heavier by factor $\sim 2$ than we assume

- Neutrino masses add up to $0.45 \pm 0.2$ eV

- Clusters allow cosmographical studies of matter density distribution $\rightarrow$ local void region in the south galactic cap (size $\sim 170$ Mpc)